An Evolutionary Algorithm for the Joint Replenishment of Inventory with Interdependent Ordering Costs

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Abstract. The joint replenishment of inventory problem (JRP) requires independence of minor ordering costs. In this paper we propose an evolutionary algorithm (EA) for a modification of the JRP. The modified JRP allows for interdependence of minor ordering costs. Our proposed EA (EARP) is a nested EA that searches for a solution to minimize the total cost of inventory replenishment. It combines an EA which uses a direct grouping method with an EA that uses an indirect grouping approach (EA_ind) by nesting EA_ind inside EARP. We test EARP against partial enumeration and show that it provides close to optimal results for some problems. We know of no other algorithm to solve this problem.

1 Introduction

Replenishment of multiple items from a single supplier is called joint replenishment. The savings realized by joint replenishment can be significant. The joint replenishment problem (JRP) is to determine an inventory replenishment policy that minimizes the total cost, TC, of replenishing multiple items from a single supplier. The TC depends on the cost of holding items in inventory (h_i), the cost of placing an order, and the demand, D_i. The cost of placing an order includes a fixed cost of preparing an order (S) and a handling cost associated with each item in the order (s_i) [4]. The problem is to find the close to optimal grouping of items for each order [4].

The JRP assumes independence of the s_i's which means s_i of item i is not affected by other items included in the same order. We consider problems for which the s_i's are interdependent. Interdependence occurs two ways. First the value of s_i may change depending on which other items are in the same order. Second, item i may be constrained from being in the same order as item j.

Two methods covered in the literature to find the best grouping of items in an order are indirect grouping and direct grouping. Indirect grouping replenishes inventory using a basic cycle time. Not all items are necessarily ordered every cycle. An integer, k_i, indicates in which cycles item will be ordered. Direct grouping divides items into disjoint groups and a fixed cycle time is determined for each group. All items in a group are ordered every cycle time for that group [3].

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In this paper we propose a nested EA (EARP) to find a near optimal solution to the JRP under conditions of interdependence. The next section describes EARP, the testing procedure, and ends with a brief description of results.

2 The Evolutionary Algorithm

EARP uses a direct grouping method to place n items into groups, G_j , where $j = 1, ..., J$, which satisfy the constraints. It then calls EA_ind which uses an indirect grouping method to find the basic cycle time, T_j, and the integer multiples, k_i, for the items in G_j. At the end of N generations, the individual with the lowest TCrepresents the best ordering policy.

Each chromosome represents a replenishment policy and contains group ids (integers) and bits representing the k_i's. See Olsen [2] for details. Each group, G_j, in the chromosome is evaluated by the following equation:

$$eval_j = \left[2 * \left(S + \sum_i (s_i/k_i) + \sum penalty) * (\sum_i h_i k_i D_i \right) \right]^{1/2} \quad (1)$$

where *penalty* is an amount added due to dependence. This is a modification of the equation used by RAND [2], an indirect grouping method. is found by where . indicates the "fitness" of each chromosome and guides the search. Parameters used follow guidelines in [1] and are: pop_size = 20, p_c, p_m = 0.01, and the number of generations is 1000 for EARP with 500 for EA_ind, the nested EA.

We tested EARP with 810 problems randomly generated within selected ranges. Results were compared with a partial enumeration process. EARP gave results equal to partial enumeration 5.4% of the time, was worse 87.3% of the time, and showed improvement 7.3% of the time. The average percent difference between EARP and partial enumeration shows EARP is 1.2% worse than partial enumeration overall for the 810 problems. These results suggest an EA solution may produce a close to optimal replenishment policy. Additional work is scheduled for publication.

References

1. Michalewicz, Z.: Genetic Algorithms + Data Structures = Evolution Programs, Springer-Verlag, New York (1996)
2. Olsen, A.: An Evolutionary Algorithm for the Joint Replenishment Problem. Ph.D. thesis, Charlotte, NC: University of North Carolina at Charlotte, USA (2002)
3. Rosenblatt, M.J.: Fixed Cycle, Basic Cycle and EOQ Approaches to the Multi-item Single-supplier Inventory System. International Journal of Production Research, vol. 23:6, Taylor & Francis, Ltd. (1985) 1131–1139
4. Silver, E.A.: A Simple Method of Determining Order Quantities in Joint Replenishments Under Deterministic Demand. Management Science, vol. 22:12. The Institute of Management Sciences, U.S.A. (1976) 1351–1361.